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THE TEACHING OF BOTANY IN THE HIGH SCHOOL

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In the teaching of any subject either of two extremes of point of view may be taken. The subject may be arranged with reference only to what will give it adequate and comprehensive organization, those who are taught being expected so to relate themselves that they grasp this logically arranged body of material. Or attention may be centered upon the individual taught, only those things being selected from the subject that contribute to the teacher's plan of educating the individual. In the first case the subject is the center of interest, while in the second it is the learner. The first case is found abundantly represented in the university where boundaries of knowledge limits in subject-matter are being widened. The second is illustrated in kindergarten and grade schools where the possibilities of the boy and girl and not those of the subject taught are the chief matters of concern. Just where one of these attitudes passes over into the other is not easy to state, but probably the transition should come at about the time that the young man or woman begins to realize what vocation he wishes to follow or in what subject he wishes to specialize. At this time educational interest in individuals does not become less necessarily, but interest in subjects has been growing so constantly and so long that it is now predominant. University men meet to discuss subjects; kindergarten and elementary-school teachers meet to discuss children and how subjects may be used with children; secondary-school and college teachers meet to discuss young men and women and the interests of the subjects to be taught. The high school concerns itself chiefly with the education of young men and women. But in the high school that sort of logical arrangement of the subject which gives best education to the students is usually that which is best for giving a comprehensive general knowledge of the subject.

I. PURPOSE OF TEACHING BOTANY IN THE HIGH SCHOOL

The primary purpose of teaching botany in the high school is found in its relation to the educational and cultural needs of young men and women. It offers an opportunity for directed experience and a study of the manifestations of life in one of its leading aspects. The method of thinking demanded by the most valuable teaching of botany is not peculiar to botany but may be developed in this field quite as well as in any other. Furthermore we need to develop the scientific method of thinking in as many subjects as possible. If people were deeply grounded in scientific thinking by experience in several fields, they would be more likely to come to use this same method when they are introduced to a new and unrelated field. Men scientifically trained in one field alone often voice ludicrous judgments in another field. High-school botany should do its part toward leading people to collect and arrange data and thereafter to make from them such conclusions as are justifiable and no others. It should teach people that judgments need often to be deferred until ample data are had, and often indeed it should teach them that the data secured do not justify any judgment. If botany and other sciences can establish a working knowledge of this method of thinking, it will help to establish the most economic and important contribution to science. A proper method of thinking is the one thing to which all other virtues are added. Professor Karl Pearson says, "Modern science, as training the mind to an exact and impartial analysis of facts, is an education especially fitted to promote sound citizenship." Professor Clifford says: "The aim of scientific thought is to apply past experiences to new circumstances; the instrument is an observed uniformity in the course of events." We are yet a long way from realization of any very large results in everyday thought and living as an outcome of scientific training. Science people themselves are sometimes examples of conspicuous failure to reserve judgment until there is a genuine basis for making conclusions. But there does exist a possibility of effecting a beneficial change in popular thought and belief and botany

may perform a part of the work to be done in bringing about such a desirable change.

The development of interest in and appreciation of nature, and particularly of biological nature, is one of the general purposes of the teaching of botany. Some such interest is inherent in the minds of young people, but this may be almost or quite removed by the kind of presentation of science subjects that is in itself lifeless and unrelated to the life interests of human beings. But few if any of the pupils of high schools will go into vocations that will entirely fail to bring them into contact with nature. Their lives may be made more full and enjoyable by having their inherent nature interests developed. A judicious direction of these interests will result in a more economic use of them, and thereby a more usable return to their possessors. Plant processes, the relation of plants to one another, their relation to animate and inanimate life, and the geographic distribution of plants are informational and cultural values of no small content.

A knowledge of plants is a source of pleasure and often of profit. Some of this knowledge we re-encounter and extend in our every-day environments. Some of it we meet in new forms during an occasional journey to more or less distant regions. Some of it enters into the material we see used in the garden, in the grocery, the drugstore, in the clothing we wear, the books we read, the treatment of our diseases, in the making of buildings, in the factory, and indeed in the experiences of every day of our lives.

But more important than this knowledge of direct interest and possible utility is the retroactive result that may come through a knowledge of certain processes in plant life. Take for example, the topic "Struggle for Existence." It is seen that many more plants attempt to live than the available water, soil, air, and light will permit to mature. The best plants, other things being equal, will be the ones that will succeed, and others must fail. Weakness and inactivity are usually the forerunners of failure, indeed are the beginnings of failure. Spasmodic activity interspersed with long periods of inactivity may give a

kind of success, but not success of the highest type. Such facts as these if properly assimilated will often produce desirable reactions upon the pupils. In the teaching of botany very little can be said concerning this ethical aspect of the work, else it becomes so insipid as to be worse than worthless and will inhibit the other values of the course. If this ethical reaction comes at all it must usually come as an "individual experience" and not as a part of the regular class exercises. The ethical aspect of science is potent and persistent but rests upon surer grounds than blatant preaching.

II. CONDITIONS OF PREPARATION OF HIGH-SCHOOL PUPILS

The amount of botanical knowledge possessed by the average entrant to the high school is so small that under present conditions nothing need be assumed at the beginning of a course in botany. Native interest will have enabled a good many pupils to gather considerable usable observations. In systems of schools where good nature-study has been done, much good botanical teaching will have been accomplished. If well-organized courses in nature-study should become general in elementary schools it will then be possible to introduce more thorough courses in botany in the high school.

The lack of previously collected data in botany is but one of the things that requires that the botany course should be simple. The immaturity of the minds to which the subject is to be presented makes entirely impossible any extended technical consideration of botany as an intricate science. These minds, however, are sufficiently mature to permit a thoroughly scientific presentation of the subject, but they do not permit adequate presentation of the details of any one or all of the sub-sciences that compose the entire subject of botany.

III. THE PLAN OF THE COURSE

The plan of the course to be used must of necessity be arranged with reference to the purpose to be fulfilled. Some of these purposes are not met by the presentation of any special fields of botany, but can be met only by presentation of all the leading special aspects. One who presents the subject from the

cytologist's point of view cannot present botany fully, neither is a full presentation possible when the plan is based solely upon morphology, physiology, taxonomy, anatomy, or economic botany. It seems axiomatic to say that a special course is not a general one. Nearly all teachers of botany say that they believe the course should be general and not special, yet our practice often gives evidence of an inconsistency at this point.

To be sure, any one of several points of view may be the line of approach, but investigation must soon lead into other points of view. A study of structure alone does not produce a general knowledge of plants. Structure is an expression of means of doing something, and we are not studying the general problem unless we try to see what it is that is being done and where and how it is being accomplished. Furthermore, pupils of high-school age are greatly interested in the ways in which human beings are related to nature, and we have not fully presented our botanical field until there is some suggestion of how it relates to man. Studying general botany by use of morphology alone is like securing a knowledge of our great transportation systems by a study of tracks, ties, frogs, and interlocking switches with no reference to why these tracks are placed where they are, or what is carried over them; or what effects are made possible in the region from which, through which, and to which they pass. Studying botany from ecology alone would be like studying the transportation system by examining the effects produced in various regions without recognizing the organic structures by means of which these effects became possible. It is true that in any course in botany, no matter how general it may be, there will be times when problems distinctly physiological, morphological, ecological, or taxonomic will receive sole attention, but merely as part of the general study, and not as classified into the special aspects above mentioned. A course in botany that is general may be almost, if not quite, as good for disciplinary purposes with high-school pupils as a special one, and should maintain interest far better, and contribute a much larger amount of valuable knowledge and a better appreciation of nature.

It seems to me that this course may best be introduced by taking up the problems of one of the plants of the kind most familiar to high-school boys and girls—one of the flowering plants. We find ourselves at once face to face with structure-roots, stems, leaves, flowers, and seeds—and must recognize and study these as structures that are related to the performance of the work that makes possible the life, growth, and reproduction of plants. Names of structures and of the plants to which they belong must be introduced in order that ideas concerning them may be expressed with intelligence, accuracy, and economy of time. Physiological experiments must be made with these structures in order to find what their work is and how it may be done. The relation of the parts of the plant to one another, to the physical surroundings, and to the other living things in the natural environment presents problems in adjustment. This sort of introduction to the problems found in plant life may be extended profitably over a considerable range of variation in flowering plants, dependent upon the personnel of the class and upon the seasons and regions in which the work is done. It should give pupils definite ideas as to the leading problems of plants, and the nature of the structures related to these problems. Further work upon special problems associated with flowering plants may well be deferred until after presentation has been made of plants simpler in form than flowering plants.

The kind of introduction to botany that is suggested above seems not only to begin the study of plants by using those forms that have entered most largely into the previous experience of the pupils, but also furnishes materials which are easily used in beginning proper methods of laboratory and field-study. It is quite possible to begin the use of complicated laboratory apparatus in the study of algae, but such may more easily and more effectively be done in studying plants whose gross structures are easily observed without the use of the compound microscope. The true function of magnification and of physiological and ecological experimentation is most easily understood when applied first to things whose structures and functions may be partially appreciated without these things.

After this extended presentation of the general problems and nature of plant life, it seems to me that the best educational benefits and most comprehensive knowledge of plants may be secured by considering plants in the order of an increasing complexity. Algae should be taken up as forms that must solve the same general problems as the flowering plants already studied, and an interest at once attaches to variations in structure, habits, and distribution as expressions of relative failure and success in making adjustments to the problems of nutrition, reproduction, and protection. When a half-dozen types of algae have been studied, the average pupil begins to classify them with reference to one another, based upon their organization for doing work. The fungi present topics of great interest to pupils of high-school age. The dependent habit of living, its effects upon host and dependent plant, lead into several important and appropriate economic problems, in addition to giving new aspects to the problems considered in the algae. An ultra-scientific attitude toward botany has been the cause of eliminating too much of the real point of life contact of general pupils with the field of botany. It would seem that even in the study of algae the pupil should get some idea of valuable and of injurious products of plants, and in the groups of fungi and the related group of bacteria the pupil should find most important relations between plants and man.

Representative forms of liverworts, mosses, ferns, and seed plants should follow, each group, as the algae and fungi, receiving morphological, physiological, and ecological consideration without the treatment being broken up into these separate divisions. In general the order of increasing complexity will determine the order of presentation of topics, and most pupils will recognize probable relationships that suggest an order of evolution of forms. All will recognize the increasing complexity as plants become better adjusted to problems of nutrition and reproduction. In a high-school course in botany it is usually unprofitable to attempt to make close connections between those details which make possible an appreciation of the various theories as to the evolution of the plant kingdom. It is one thing

to recognize the fact of an increasing complexity in plant forms and quite another to appreciate theories of organic evolution. Such an order of presentation as suggested establishes the foundation for further work in the details of relationship of groups in case such is ever attempted. What is more important relative to this point, is that it furnishes an organization for future observations and readings for all who in maturer years again consider the problem of organic evolution. It must be clearly understood that the teaching of the doctrine of organic evolution is by no means the leading and immediate purpose of the above arrangement of plant types.

Much of the material that has general educational value can most easily be arranged under such special topics as "Geographical Distribution of Plants," "Plants and the Industries," "Forestry," "Plant Breeding," "The Cereals," etc. Although most of this material is not accessible to laboratory and field-study, it is of such importance as to demand that it be included in a course that proposes to give adequate general conceptions of the field of botany.

IV. THE TEACHER

After all is said regarding the first three points of this discussion, it must be recognized that the teacher is the determining factor in the teaching of botany, as in any other subject. In most respects the pupils of any two schools are quite similar. Yet we often find that when using the same plan of course, the same textbook, and quite similar laboratory and field opportunities, all the difference between failure and success is shown in the two schools. A thoroughly good teacher will make some sort of organization of his course so that good results may follow. A poor teacher will be more efficient through being furnished good plans, equipment, textbook, and collateral reading material. It were often better for pupils and for botany, as for many other subjects in the curriculum, if the subject could be temporarily dropped, but such is rarely a feasible plan. It were far better if only thoroughly good teachers of botany were employed to teach the subject, but unfortunately there are not

enough to go around. Then there is a great difference of opinion, and doubtless always will be, as to just what constitutes a good teacher of botany. Some of the qualifications which it seems to me a good teacher of botany should have are given below.

1. There should be a thorough knowledge of the subject-matter of general botany and zoölogy with an intimate knowledge of the details of some particular field in either botany or zoölogy. It is assumed also that some knowledge of other related sciences is necessary. Too often, however, the teaching of botany is left to a person who is primarily the teacher of physics and chemistry, and who in some cases has no preparation in botany. Because of the presence of the life factor and the complications of the changing responses made in changing environments, it would seem better to leave physics to a botany teacher who is not prepared in physics than to leave botany to a physics teacher not prepared in botany. This conclusion may be due to a prejudice on the part of one engaged in teaching botany. It must be recognized that in all but the largest high-schools the "teacher of sciences" needs to be well prepared in both physics and botany as well as in other sciences.

The fields of botany and zoölogy have so many things in common that the teacher of either subject should have a good general knowledge of the other. Furthermore, if he has intimate knowledge of the details of some subdivision of one field, he will have been introduced to the method of research in such a way as to enable him to appreciate the difference between the known and the unknown. Some appreciation of the limits of knowledge in one field will help greatly to remove a feeling of necessity of knowing about all points that may arise in the process of teaching. Professional integrity has been seriously interfered with on the part of a good many people who could not be expected to know what they felt they should know. The old teacher said: "John, what is the function of the spleen?" John replied, "Professor, I knew that this morning, but I have forgotten." "You rascal," said the teacher, "all the world is wanting to know and you have forgotten it."

2. The teacher should have definite ideas concerning the function of botany in high-school education. This does not mean that to be a good teacher of botany one must have compassed the territory of educational theory in general, though some such work would doubtless be helpful. But one should know what he is going to try to do with botany if he assumes to teach it. We do occasionally arrive at places to which we did not intend to go, but we more often arrive at objective points selected before starting. Aimless botany teaching cannot produce most valuable results.

3. The teacher needs to know the relative development of the pupils to whom botany is to be taught. He needs to know their general ability, their ways of thinking, and the amount of botanical data upon which he may begin to build. There are still a good many college graduates who do the high-school boys and girls the honor of supposing them to be as mature as they themselves were when they took their college courses in botany. They attempt to teach them the quality and quantity of material that they got in college, and in the same way. The teacher needs to know the minds of the pupils well enough to enable him to defend them against some of the botany textbooks in which are presented courses entirely too technical for high-school pupils.

4. The teacher should have an active interest in teaching botany and in studying problems related thereto, since a truly active nature interest on the part of the teacher is infectious, just as truly as dead and uninteresting teaching develops immunity to nature-interest. Nearly all pupils possess an inherent interest in plant life which, if the teaching embodies proper interest, will give rise to varied spontaneous expressions.